# General Volcanology

Technically, a volcano is a vent or chimney connected to a reservoir of molten material, a magma chamber, within the earth's crust. Ejected material usually accumulates around the opening, the vent, to build a cone, or "volcanic edifice." As popularly used, the term volcano includes both the vent and accumulated materials.

## Origin of Volcanoes - Basic Considerations

Temperature of the earth's crust increases with depth. Rate of increase varies with locality and depth, varying from 86° to 122°F per mile. At great depths, the rate of increase diminishes. Forty miles below the surface, the temperature probably approaches 2200°F, the point where most materials liquefy. Earthquakes, however, demonstrate the solidity of such material, which remains solid or semi-solid due to tremendous pressure of overlying rock.

Magma usually collects at various levels within the crust to displace and/or incorporate surrounding rock and form a reservoir, the feeding chamber. These pockets of molten material near the surface may be formed by:

(1) Reduction of pressure, typically occurring in volcanic mountain belts.

(2) Increase of temperature, usually caused by reduction of pressure, radioactive breakdown of elements such as uranium, thorium, and/or earth movements along faults in the crust.

(3) Combination of these.

Once magma forms near the surface crust, it tends to rise, or to be forced to the surface by self-contained gases. A variety of formations may develop:

Basalt plateaus. Magma, under low pressure, may erupt forming swarms of fissures, to spread as floods of basaltic lava. The Northwest's Columbian Basalt Plateau is North America's finest example.

Shield Cones. Copious swellings of more viscous lava construct volcanoes which in profile resemble low domes or inverted saucers. Examples are Prospect Peak, Mount Harkness and Red Mountain.

Cinder Cones. Magma, under high pressure, will erupt explosively to form steep-sided volcanoes. Usually they are symmetrical in shape and are formed rapidly. Mexico's Paricutin, for example, grew 1,000 feet by the end of the second month. Generally, cinder cones are less than 1,000 feet high. Examples include Red Cinder Cone, Hat Mountain, and Cinder Cone.

Composite Cones. These are formed of alternate layers of lava flows from effusive eruptions and fragmental material from explosive eruptions. When exposed, a banding effect is evident. Examples include the high peaks of the Cascade Range: Mount Rainier, Mount Hood, Mount Shasta and ancient Mount Tehama.

Plug Domes. Extremely viscous masses of lava emerge rapidly and "en masse" from a vent to form a steep-sided, bulbous mound. These may vary from tens to thousands of feet in height. Lassen Peak is considered one of the world's largest plug dome volcanoes. Others are Chaos Crags, and Reading Peak.

Materials ejected from a volcano vary in chemistry as components separate in the magma. As magma cools, the first minerals to crystallize are poor in silica, but rich in iron, calcium and magnesium. As cooling progresses, minerals richer in silica and potassium develop. Heavier crystals, rich in iron, calcium and magnesium sink toward the chamber floor and leave the lighter, silica-rich residual liquid on top. Evidence suggests that eruptions may occur at any stage in the cooling and separation process, and fissures may tap any level of the feeding chamber.

A major effect of crystallization within the magma chamber is a concentration of gas within the remaining liquid. Ultimately, the gas pressure becomes too great for the reservoir roof to withstand and eruptions begin. Gas then becomes the driving force within a volcano.

Initial eruptions or explosions, whether gas, magma or a combination of the two, reduce the pressure and allow more gas to separate from liquid. In this manner, eruptions become self-sustaining.

## The Product of Volcanoes

The principal gas, steam, is generally more than 95 percent of the total discharge, seldom less than 82 percent. Carbon dioxide is the second most common gas. Sulfurous gases such as sulfuric acid, $H2SO4$, create the characteristic odor of volcanoes. However, less is released than of water and carbon dioxide. Gases released in minor amounts include hydrogen, ammonium chloride, carbon monoxide, nitrogen, chlorine, and fluorine.

## Naming of Volcanic Products

Fragmented or pyroclastic products are named according to size, texture, and composition of materials. Fine-sized materials, smaller than peas, include dust and ash which, when compacted to rock, form volcanic tuff. Fragmental material between pea and walnut size is termed lapilli. Material larger than walnut size is termed block, which when compacted to rock, forms volcanic breccia.

Volcanic Bombs are almond shaped, with twisted "ropes" of lava and cooling cracks. These form as large blobs of molten or semi-solid lava which solidify while falling through the air. Bombs compacted into rock with other large, round ejecta form agglomerates.

Highly vesicular, frothy, light-colored ejecta, with density often low enough to float on water, are termed pumice. Pumice is generally siliceous and acidic in composition. Highly vesicular, frothy, dark-colored ejecta, less siliceous, basic and more dense than pumice is termed scoria.

## Types of Eruptions

Hawaiian: Exemplified by basaltic shield volcanoes such as Kilauea. Extremely hot, fluid lavas pour from summit vents and also from fissures on the mountain flanks. Fragmental material is minimal, as gases are liberated quietly.

Strombolian: Named after a volcano off the coast of Sicily. Rhythmic discharges occur at intervals of seconds or minutes, ejecting pasty, glowing clots of magma (scoria) which cool to form bombs and lapilli. Eruptions are accompanied by white vapor clouds. A few solid fragments are expelled. Lava swellings are on a very small scale, usually more viscous than the Hawaiian types. A cinder cone is the characteristic form.

Vulcanian: Named for Vulcano, Italy. Explosive discharges of viscous magma are spaced by intervals of quiescence. Solid, angular fragments are ejected, together with pasty lumps of magma-bombs and frothy pumice. The final phases are characterized by gas eruptions, which may continue hundreds of years after the last magma eruption. Huge cauliflower-like clouds of steam charged with fine ash are often formed. Flows are rare, and characteristic of siliceous magmas; those that do form cool to thick, stumpy tongues of obsidian.

Ultra-vulcanian: Only rock fragments are discharged, no lava. Normally these low temperature steam blasts occur as the first outbreak of a new volcano, or as initial explosions of older volcanoes after periods of dormancy.

Pelean: Named for Mt. Pelee on the island of Martinique, West Indies. Following production of highly viscous magmas, intense explosions of superheated steam blast great amounts of glowing ash and large fragment as glowing avalanches, or nuee ardente, over wide regions. Similar eruptions occurred at Lassen Peak in 1915.

Fissure: Lavas escape from fissures, rather than from central vents. More copious flows produce no volcanoes, but rather large, level plateaus such as the Columbia River Basalts.

The nature of volcanic eruptions is determined primarily by gas pressure and viscosity of the magma, both of which are controlled by magma composition and stage of cooling. Lava viscosity varies inversely with temperature and gas content.

The lower the viscosity, the greater the tendency to swell quietly and form low-lying structures. These lavas are of basic (basaltic) composition, relatively low in silicon dioxide, about 50 percent, but relatively high in iron and calcium oxide, about 20 percent.

High gas pressure is correlated with high viscosity, which increase the tendency toward explosive activity and formation of conical structures. Generally, these lavas are more acidic (rhyolitic dacitic) in composition, relatively rich in silicon dioxide, about 70 percent, but poor in iron and calcium dioxide, about 3 percent.

The layman's term, cinders, is used to include all fragmental material between ash and block in size.

Lava is the general term for all volcanic material extruded above ground, whether liquid or solid.

Lava character is determined by chemical composition, gas content, magma temperature and environment where extruded. Surface flows of lava are usually termed pahoehoe if appearing ropey or as cordlike corrugations, and Aa if appearing rough or blocky.

Lavas are classified according to composition and textural character, such as percentage and size of gas cavities, amount of crystallization, and selective size of crystals. Composition, the primary criterion for classification, determines most characteristics of flows. Lavas relatively poor in silica and rich in calcium, iron, and magnesium, the basalts, are more fluid than lavas with the reversed composition, the rhyolites and dacites. Occasionally these move greater distance and at greater speeds, to form thin layers, than the rhyolitic or dacitic lavas, which are pasty and sluggish. Basaltic lavas are generally 1800° to 2220°F. Siliceous lavas are generally 1100° to 1550°.

Andesitic lavas are intermediate in chemistry between basalt and dacite.

Pillow lavas form whenever lava flows into water and cools rapidly.

## Caldera versus Crater (Hans Rick's Classification)

| **Caldera** | **Crater** |
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| All calderas are related to volcanic topography. | Many craters are not related to volcanic topography. |
| Volcanic craters are inseparably related to conduits. | Calderas are not related to the roof of the reservoir. |
| Volcanic craters are the eruption vents. | Calderas are never entirely eruption vents. |
| Volcanic craters are the vents through which ejecta passes. They are positive, active volcanic forms. | Calderas are the result of change in state or volume within the underlying reservoirs. They are negative, passive forms. |
| Volcanic craters occur during the active, growing periods of volcanoes. | Calderas are marks of decadence and age, although caldera formation may be followed by renewal of activity. |